DOCUMENT RESUME

ED 338 604 SP 033 413

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TITLE Restructuring Teacher Education: Integrating Science/Mathematics Methods Course and Student Teaching--the Northridge Experience.
PUB DATE Feb 91
NOTE 25p.; Revised version of a paper presented at the Annual Meeting of the Association of Teacher Educators (71st, New Orleans, LA, February 16-20, 1991).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Elementary Education; Higher Education; *Integrated Curriculum; Mathematics Instruction; *Methods Courses; Methods Teachers; Models; Preservice Teacher Education; Science Instruction; *Student Teaching; *Supervisory Methods; *Theory Practice Relationship
IDENTIFIERS California State University Northridge; *Knowledge Base for Teaching; *Reflective Teaching

ABSTRACT

The goal of teacher education is to prepare prospective teachers to become reflective practitioners who are able to make pedagogical decisions in light of sound theory. This report describes a model for integrating science and mathematics methods with student teaching. Efforts to maintain a critical bond between theory and practice is one component of the Multiple Subject Credential program at California State University, Northridge. Several assumptions giving foundation to the program to prepare elementary school teachers are highlighted as are the broad elements of the credential curriculum. Focus is on one component of the program consisting of a course in curriculum and instruction for teaching mathematics and science in the elementary school and the accompanying student teaching practicum. The significance of several features of this methods and student teaching component are discussed. They are; (1) methods instructors serving as field supervisors; (2) collaborative lesson planning; (3) curriculum analysis and use--textbooks and other curricular materials; (4) microteaching; (5) observation and peer coaching; (6) supervision; and (7) seminars. The program represents a concerted effort of several departments to provide for student teachers a broad knowledge base as they prepare to teach students from culturally, linguistically, and experientially diverse backgrounds. (LL)

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ED338604

Restructuring Teacher Education: Integrating Science/Mathematics Methods Course and Student Teaching - The Northridge Experience

A version of this paper was originally presented at:

Association of Teacher Educators Conference
New Orleans, Louisiana, February 16-20, 1991

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ABSTRACT

The authors express the view that the goal of teacher education is to prepare prospective teachers to become reflective practictioners who are able to make pedagogical decisions in light of sound theory. Efforts to maintain a critical bond between theory and practice in one component of the Multiple Subject Credential program at a major California university are discussed. Several assumptions giving foundation to the program to prepare elementary school teachers are illuminated as are the broad elements of the credential curriculum. The authors elaborate on one component of the program consisting of a course in curriculum and instruction for teaching mathematics and science in the elementary school and the accompanying student teaching practicum. They discuss the significance of several features of this "methods" and student teaching component - that methods instructors serve as field supervisors, the projects and activities through which preservice teachers develop reason in determining educational aims and means for accomplishing them, and the manner in which supervision is carried out - in their conducing to preservice elementary teachers developing as reflective practitioners.

Restructuring Teacher Education: Integrating Mathematics/Science Methods and Student Teaching - The Northridge Experience

D. Kretschmer, A. Sia & H. Bagheri

> What schools need are prospective teachers who are both theoreticians and practitioners, who can combine theory, imagination, and techniques (Giroux, 1990).

Introduction

The conventional approach to pre-service teacher education program follows the methodology - student teaching sequence. This seems a logical approach: give teacher aspirants the theory first and then provide them an avenue to put this theory into practice. While this model remains largely unchallenged, this linear approach may pose some delay in the theory - practice bond linkage. The pre-service teacher may not be able to draw critical linkages between ideas brought forth in methods class and the application these ideas in student teaching a semester later.

Following the traditional approach to teacher preparation may also pose some constraints to some educational institutions which address state mandates regarding the number of credit hours required for teacher credentialing. The California State University, Northridge (CSUN), along with some other CSU institutions, takes these state-mandated realities in modifying their programs. Likewise, the push for offering Year-round schooling may affect the sequencing of pre-service methods courses alongside with student teaching. With nearly every school district within Los Angeles County adopting a year-round school calendar, the faculty of the Department of Elementary Education at CSUN is faced with the challenge of offering various permutations of methods courses and student teaching assignments. To accommodate this county-wide thrust as well as meet state requirements for number of contact hours in methods classes, we may have to offer methods courses partly previous to and partly concurrent with student teaching. This certainly is a deviation to the linear approach delineated above.

Sparks-Langer, et al. (1990) criticize the traditional form of teacher education for its emphasis on technique divorced from consideration of broad purposes. They call for a re-directed emphasis on helping prospective teachers develop an adequate social and educational philosophy.

In light of the present realities and needs, therefore, we feel that the conventional approach to teacher education needs to be restructured to reflect the philosophical view on teaching shared by the faculty and to address state requirements and NCATE Standards on credentialing teachers.

It is our view that the goal of teacher education is to prepare prospective teachers to become reflective practitioners who are able to make pedagogical decisions in light of sound theory. We

shall address this goal as we describe our own experiences in integrating mathematics and science methods with student teaching.

To provide context for this paper, we discuss the external factors impacting CSUN and its educational mission, assumptions affecting our multiple subject credential program, and provide a description of its curricular components. If teachers are to develop as reflective practitioners, a close theory-practice linkage between the ends and means of education must be established. Dewey's reflective thinking and action and Shulman's pedagogical reasoning are revealing of how teachers' knowledge serves them as pedagogical decision makers. A model depicting our view of the linkage between theory and practice encapsulates our efforts to integrate mathematics and science methods and student teaching.

External Factors and Assumptions

Nearly one-half of the teachers employed in Regions E and F of Los Angeles Unified School District received their pre-service training through CSUN. The student population in Los Angeles schools reflect heightened changes in lifestyle and demographics seen in other cities and regions of the nation: "minority" students in Los Angeles comprise well over 50-percent of the total, with those of Hispanic origin representing the largest group; for nearly one-third of California school children, a language other than English is spoken in the home; and close to 50-percent of California's limited English proficient inhabitants reside in Los Angeles County. The character of the student population of Los Angeles schools is in such a state of flux that teacher education institutions must continuously turn an eye towards providing for students of varying experiences, learning styles, culture, and linguistic abilities.

These and other national, state-wide, and localized trends impacting on schools form the foundation of a presuppositional core around which the Multiple Subject Credential Program at CSUN is constructed. Some of these underlying assumptions are:

California is multicultural in its people, with school achievement unevenly distributed by ethnic groups and many children of those ethnic groups labelled as "At Risk".

Schools are not preparing students to work well in a racially integrated and democratic society.

A move toward an information based, high technology, interdependent, and rapidly changing economy is accelerating. Many of the kinds of jobs available today will not exist by the time primary school aged children graduate from high school. These children will participate in a world we can not accurately predict.

Education must give increased attention to providing students with higher level thinking, communication, and social skills.

Teaching methods must promote interdependent and cooperative educational experiences.

Literacy across the curriculum, and in particular problem solving skills, will be increasingly important for citizens to meet the demands of the ensuing century.

Teacher and parent empowerment and business and community involvement are influencing the traditional roles of these groups.

Fiscal resources of LAUSD and other districts, in a decline, will result in a dependence of teachers upon CSUN courses for continuing education and in-service offerings.

The relationship between the university and outlying school districts that the university serves need be a responsive one. A program designed to prepare individuals to assume the responsibilities of contributing to the emotional, physical, social and intellectual lives of a diverse population of school children must be able to accommodate to changes in the external environment that impact on schools. Given the internationalization of California, teachers must be prepared to adjust the curriculum to better meet the diverse needs of students for life in the mainstream of a rapidly changing and uncertain world.

Curricular Components

It is through a well-articulated program of coursework and associated experiences that the Department of Elementary Education at CSUN endeavors to develop understanding and competency in its prospective teachers in four main areas. One is pedagogical competence in the design of curricula, instructional planning and execution, and classroom organization and management. A second is an understanding of the needs of students of different cultural backgrounds and linguistic abilities, and as regards different intelligences, gender, learning styles and experiences. A third is an understanding of the broader purposes of an education. Fourth, a critical competence mediating the other three, action based on a willingness to examine one's own perspectives about society, schools, and education in general, of the social function teachers and schools perform, and the ability to critically examine curricular materials.

The Elementary School Curriculum - Mathematics and Science, the "methods" course concerned with the development of curricula and instruction in these subject areas in the elementary school classroom, and the accompanying student teaching component, represents for most credential candidates, the culminating experience of the Multiple Subject Credential program at CSUN. As a whole, the program reflects a responsive attitude to the foregoing assumptions and the standards set forth by California's governing agency, the Commission on Teacher Credentialing, those standards giving significant emphasis to preparing students to teach in a multilingual and multicultural society. The "fifth year" of professional preparation for teaching at the kindergarten through sixth grade levels is comprised of thirty semester hours of coursework (a maximum as stipulated by the Commission)[1]. The program requires two foundation courses. One, educational psychology, is an overview of theoretical positions on learning, development,

and instruction as they shape the outcomes of a child's education, and is analytical in exploring alternative missions of the school from a psychological perspective. The second foundation course, "Education in American Society" brings together educational sociology and philosophy in a critical examination of the current conditions of American public schools and proposals for reform of the urban elementary school wrought by problems brought on by contemporary social conditions. An enhanced understanding of the children who attend urban schools is gained through courses selected from Chicano and Pan-African Studies departments on the CSUN campus.

A course in developmental reading instruction focuses on the place of reading in the Language Arts and other content area curricula, theory and concepts from current reading approaches and word attack strategies, and materials and methods used in directed reading instruction of English and non-English speaking students. This course is directly coupled with a more methodology-oriented requirement specific to curriculum and instruction in teaching English as a Second Language in the bilingual and multilingual classroom setting.

Additional courses requisite to field practica concern basic number concepts, and the physical development and methods of instruction in the area of physical education. Rounding out the requirements that must be met prior to or concurrently with a candidate's first semester of student teaching is a methods course in curriculum and instruction in language arts and social studies.

Upon enrolling in the methods course in mathematics and science teaching and the accompanying student teaching component, teacher candidates have completed 12 semester credit hours of methods instruction in the various content areas, engaged in field experience working with children (e.g., counseling, tutorial, coaching capacity), and have been participant/observers in a variety of settings offering a range of perspectives[2] and have student taught on a daily basis for a period of eight weeks. The second semester of student teaching, in many respects, represents the capstone of a well-articulated sequence of professional education courses and offers the opportunity for the individual candidate to apply the knowledge base accumulated in requisite foundations and methods courses in assuming full responsibility for the realm of classroom affairs, whether it be developing curricula, instructing students through these curricula, structuring a classroom managerial system, or assessing students. It is to the specifics of this culminating experience and the manner in which a critical bond between different perspectives for viewing teaching and learning and the practice of teaching in the content areas of mathematics and science that we turn full attention.

The Theory-Practice Relationship

Many teachers discredit the value of theoretical knowledge in the practice of their craft. Teachers of teachers are often viewed as being too far removed from the practical realities of classroom life. All of that "nonsense" passed off in the college or university under the pretense of teacher education has little meaning for teachers in their practical worlds (Griffin, 1986). We view theoretical knowledge as playing a critical role in the education of teachers, in both the practical component of teacher education as well as in establishing a firm foundation from which can emerge effective practice. The point to be elucidated here is this: teaching is a normative enterprise and in preparing those to Teach, a primary emphasis must be given to developing the ability to critically reflect on the origins, purposes, and consequences of one's behaviors as a teacher and to cultivating the pedagogical and intellectual skills necessary for directed self-growth. In addressing the issue of the cultivation of the reflective teacher and therefore the necessity to maintain a close bond between theory and practice, we draw from a number of voices.

Dewey (1904) wrote of what was to befall a student-teacher who divorced scholarship from method. The student who bases his methods of teaching solely against that which he has seen succeed or fail in the classroom of the seasoned teacher is opting for the acquisition of immediate skill at the cost of power to continue growing as a teacher. And while the advantages of acquiring a repertoire of means to secure immediate results may be borne in the first year or so of teaching, progress beyond may be a matter of simply honing those skills already in one's possession. While such individuals, it may be said, know how to teach, they are not students of teaching - they lack "intellectual independence" (Dewey, 1904; p.16). The value of practical work does not lay in coming to the recognition that certain methods of teaching work while others do not, but more in knowing *how* and *why* they work. The teacher is to be an "independent judge and critic of their proper use and adaptation" (Dewey, 1904; p. 19).

Principled technique, then, forms part of the knowledge base of the teacher. Teaching is a matter of adapting one's knowledge base to specific contexts of the moment. Schwab echoes this notion in his analogy of teaching to an art form:

> Every art has rules but knowledge of rules does not make an artist. Art arises as the knower of the rules learns to apply them appropriately to the particular case. Application, in turn, requires acute awareness of the particularities of the case without complete abrogation of the rule. In art, the form must be adapted to the matter. Hence, the form must be communicated in ways which illuminate its possibilities for modification (Schwab, 1973; p. 265).

Alternative perspectives of teaching have been suggested, positing the practice of teaching with the practice of medicine and practice of law. Summarizing Shulman (1986a), some part of the knowledge base of the physician is empirically based, an accumulation of the results of medical research giving to the derivation of principles that guide decisions. Case knowledge is

accumulated in the physician's residency and internship programs in which principles are applied in the treatment of specific conditions.

The knowledge base of the attorney, on the other hand, is a foundation of normative rather than empirically derived principles. Normative principles take the form of laws, regulations, and statutes regarding such issues as justice and personal rights. One's education as a lawyer is a process of locating and classifying cases and reasoning analogically from these cases serving as precedents to the particulars of the case at hand.

It is our view that a blend rather than any single perspective best characterizes teaching and is suggestive of what forms (or should form) the knowledge base of teachers and how teacher educators might go about their business. Regarding that knowledge base, the activities of teachers are seen by many as proceeding from, at best, only a weak cognitive basis. Those whose efforts are in the direction of reforming teacher education (e.g., Shulman, 1987) argue that there exists a rich and elaborate knowledge base existing as an aggregate of understanding and skill in the content areas, pedagogy, of learners and their characteristics, of educational contexts, and knowledge and beliefs regarding educational purposes and ends.

This knowledge is the content required of the learner to *initiate* a process of liberating the prospective teacher from the constraints of convention and dogma (Fenstermacher, 1986). The aim of a teacher's education is "to supply teachers with the means to structure their experiences in ways that continually enlarge their knowledge, reasoned belief, understanding, autonomy, authenticity, and sense of place" (Fenstermacher, 1986; p. 46). One of the first tasks towards pedagogical competence (the goal of those of us who provide instruction in methods and serve in a supervisory capacity in the field) is "to assist teachers in framing the practical arguments undergirding their actions", and the next "to assist in the teacher's appraisal of the premisses in the practical argument" (Fenstermacher, 1986; p. 46). Thus, rational processes guide a teacher's thinking about what *should* be going on between the various interacting elements of the classroom.

Reflective Teaching

While we have come to an understanding that a professional teacher education program is to have a liberating effect upon the teacher, many teachers continue to be trained as technocrats through a curriculum of sterile methodologies. Underlying such a technocratic approach to teacher education, one that places greatest emphasis on "what works" and "how to" organize and manage a classroom, implement "teacher-proof" curricula, and evaluate students through pre-defined forms of assessment is that there is little room in the work of the teacher for critical thinking. Giroux (1990) asserts that programs driven by such instrumental and pragmatic ideologies and that define teaching in purely technical terms contribute to devaluing and deskilling the work of the teacher.

Through a different pair of spectacles, however, teaching is an intellectual activity, achieved through an integration of thinking with practice. Teachers are reflective practitioners.

In guiding prospective teachers in their development as reflective practitioners, teacher educators would be disserving of their students if practice were associated solely with drill in the application of skill to "standard cases". Teaching requires certain routinizable competencies the development of which can be fostered through drill and application. But further, it requires critical skills that are nonroutinizable and that call for developed intellect. There is a limit to which the practice of the teacher's craft is improved through continued effort to develop teaching facilities. Beyond this, improvement is a matter of developing "strategic judgement" to "guide choices", "evaluate outcomes", and "reflect upon alternative principles of strategy in light of such evaluation" (Scheffler, 1965; p 103).

Dewey's (1933) analysis of reflective thinking serves as a useful conceptual framework for illuminating the critical skills of the teacher. Reflective thinking is purposeful, tending towards a conclusion or end such as an understanding of a whole in relation to its parts or the solution of some problem confronting us. Reflection entails a conscious effort directed towards that end, achieved through some means - a theory to account for the relations or some plan or strategy towards solution. The belief that a proposal will serve its end is grounded in the evidentiary adequacy of facts gathered in the reflective process, knowledge relevant to the situation, and prior experience. Reflective activity results in action that is justified by reasons.

The essence of Shulman's (1987) pedagogical reasoning is the teaching correlate of Dewey's reflective activity. His model is illuminating of the role of the knowledge base in the work of the teacher and suggests possibilities for developing the intellectual capacities of teachers. As teaching is concerned with both means and ends, reasoning underlies the determination of both the aims of education and the executable strategies for accomplishing them. Comprehension serves a beginning. Teachers must understand the subject matter to be taught, the concepts and principles the subject encompasses, and its syntactic and substantive structures, and additionally, the aims of education - understanding and skill, literacy, enjoyment of freedom and leisure time, responsibility, dispositions conducive to continued learning, and the like. Coupled with this understanding is belief in the appropriateness of these aims, a belief that compels one to action towards achieving them.

Once these purposes are understood, the task is to transform them into a strategic path towards fulfilling them. The several phases involve a critical examination and interpretation of materials for teaching; thinking through the various strategic devices for conveying the teacher's understanding to the mind of the student; selection from amongst a repertoire of instructional strategies; and consideration of the needs of students and the adaptation of that which is to be

learned to students of different linguistic abilities, culture, experiential backgrounds, and prior understandings.

Once a teacher has reasoned through the means to achieving some predefined end, the step to follow is the implementation of the strategy. Some measures must then be taken to assess the degree to which students have attained the desirable ends. Evaluation is both informal in the case of the ongoing "checking for understanding" during the instructional process, and more formal in the sense of assessing student acquisition of content, process skills, and appropriate social behaviors.

Reflection (in a lesser sense than Dewey's concept) entails looking back, recounting the sequence of events that occurred in the lesson, the interaction between students, students and teacher, and student and materials, as well as an analysis of the results obtained through assessment procedures. This leads directly into the final phase of the model in which the teacher arrives at new comprehension. It is a phase in which a teacher augments his or her understanding of the purposes of an education and the means for achieving them, subject matter content, and students, thereby widening and deepening the knowledge base.

Pedagogical reasoning is thus a knowledge-generating process conducive to the continued growth of the teacher. It is illuminating of how the teacher's knowledge in the content areas; understanding and beliefs in the ends of education; pedagogical knowledge of classroom organization, instructional models, questioning strategies, demonstration of principles, and the like, undergirds the actions of the reflective practitioner.

Mathematics and Science Methodology: Integrating Theory with Practice

In combination, the methods and student teaching courses of the professional preparation of the elementary teacher at CSUN represents an effort to introduce credential candidates to essentially every dimension of the world of the teacher. The course in "methods" - The Elementary School Curriculum: Mathematics and Science - and the accompanying student teaching practicum are taken concurrently and are therefore viewed as two interrelated components of a single "experience". The methods course provides 45 hours of instructional time condensed into the first seven weeks of a fifteen week semester and is devoted to developing curriculum and instructional approaches to teaching mathematics and science in the elementary classroom. The second component, student teaching, immediately follows methods during the latter eight weeks of the semester. In such a program of combined methods instruction and student teaching, we expect that what students gain in the first segment will be extended, expanded and applied in practice teaching. Actually, we can do more than hope that that this is actually the case due to a simply-stated feature of the Multiple Subject Credential program at CSUN: those of us who provide instruction in

methods to a class of prospective teachers also place those same students in the schools for their second semester of student teaching and follow them into the field and serve as their university supervisor.

This instructor *qua* supervisor feature is not to be trivialized; we feel it is a significant factor, contributing to the strength of the program in several ways. First, the university instructor/supervisor maintains a close association with some three to five schools and the teachers at these schools. Such an association facilitates placing student teachers with supervising teachers who share similar educational ideologies thereby enhancing the potential for the two to develop a close personal and professional relationship based on mutual respect and open communication. In most elementary teacher education programs that we are familiar with, placement of student teachers is carried out by a field coordinator who neither provides instruction in methods nor supervises in the field. Therefore, CSUN's program represents a significant departure from common practice.

Second, with such a significant amount of the methods instructor's allocated time devoted to visitation in the schools, he or she is aware of the "realities" of teaching at the elementary level. University faculty serving in this capacity can and do assume varied roles as supervisor and observer or participant/observer. We maintain familiarity with the contextual factors - character of the student body, of different classrooms, linguistic abilities, cultural diversity, and so forth - specific to schools and individual classrooms and can guide student teachers to adapting their teaching to those factors. A number of supervisors in-service teachers at these schools in the teaching of mathematics and science and demonstrate lessons in the classrooms of supervising teachers. Additionally, observation and participation in the life of schools and classroom establishes a feedback mechanism through which insights stimulated from close contact with students and teachers can be used in revisions of the methods course curriculum.

Third, and most important to the specifics of this paper, is that in the capacity of both instructor and supervisor, we can better insure that the theory-practice linkage is established and maintained. The various projects and assignments that prospective teachers complete in the methods segment are intended to initiate thinking and activity directed towards their assuming the role as a professional in the school environment. In assisting teachers to reflectively make use of the knowledge base accumulated in previous coursework and experiences through a close theory-practice bond, we can better contribute to teacher's developing the intellectual capacities and skills essential to the work of the teacher.

Following is a discussion surrounding the variety of experiences in the methods - student teaching component of the sequence discussed above. We feel they are representative of a curriculum designed to (1) foster prospective teachers' desire to continue in a path of increasing

one's understanding of key mathematical and scientific concepts and the structural features of their disciplines, (2) to analyze and implement a range of effective teaching strategies for mathematics and science based on sound theory and/or research, and (3) develop critical pedagogical skills to enable the teacher to be a developer as well as a user of curricula, instructional strategies, and approaches to managing the classroom environment. In connecting the concepts and principles from their courses with the reality of the classroom, it is our hope that those who aspire to teach will use their knowledge base in making more thoughtful and appropriate decisions in their future.

Curriculum Development: Lesson and Unit Planning Students are assigned to and meet in groups to undertake the task of developing a number of lesson plans that could be used for instruction in mathematics and science at different grade levels. Collaboration between students in this aspect of the course has potential to serve practice in at least two ways. First, it brings together students of different backgrounds and educational ideologies and provides an opportunity within a specific context for sharing individual perspective. Second, it is hoped that through such interactive planning, teachers will adopt favorable attitudes towards and come to view curriculum development and instructional planning as optimally conducted as a collaborative effort.

In the design of lesson plans, students must give consideration to a number of criteria beyond the objective students are to meet, the instructional strategy, and the assignment of practice and follow-up activities.

Objectives We feel it is important that students give thought to the value of the objectives students are to meet and therefore are asked to provide a rationale for the selection of objectives from several perspectives, e.g., psychological, sociological, standpoint of the nature of the subject matter.

Process A second criterion has its base in psychological, epistemological, and structural perspectives for viewing teaching and learning mathematics and science. We want prospective teachers to come to view mathematics as more than computation and science a collection of facts. In their lesson planning, these prospective teachers must give attention to actively engaging their students in developing process skills in these areas. Students in our classes themselves engage in hands-on activities with a variety of educational materials. We encourage free play and open-exploration of manipulables that children often view as "toys" with first contact. Learning through free-exploration, while not a result of directed teaching, does occur incidentally. Materials are sorted, counted, arranged into patterns, and along the way, relationships discovered.

Teaching and learning with the aid of manipulatives contributes to learning in still other ways. Through such an approach, teachers give attention to students who learn best through tactile and kinesthetic modes. Students' self-concept and feelings of efficacy are enhanced through their

engagement in more satisfying and successful learning experiences. Students are less anxious about learning mathematics and science. A process orientation enables teachers to give greater focus to students developing a conceptual level of understanding from which underlying rules of computation can be derived and better understood. Additionally, this orientation provides avenues for exploring students' conceptions and opportunities for students to engage in activities to either confirm their conceptions or cause them to overthrow them. Finally, as in the specific case of science, we believe process is conducive to students developing an understanding of the nature and structure of science.

Instructional Models A great number of instructional models valuable to prospective and practicing teachers as frameworks for the design of lessons occur in the literature and are compiled in such formal arrangements as "families" in texts (e.g, Joyce and Weil, 1986). We feel these models ought not be blindly implemented in one's teaching of a skill or a concept. In our work with teachers on the subject of these models, we give attention to their critically examining the models for underlying assumptions regarding the acquisition of knowledge and the role of the teacher and the learner, as well as possibilities for adapting these models to particular teaching situations.

Use of Puzzling Situations Students are led to reflect on the value of the discrepant event in the teaching of science and in the student's construction of new understanding of science concepts. In implementing strategies in which puzzling situations are presented, teachers should encourage divergent thinking and serendipity. Teaching from the discrepant event is an approach consistent with constructivist psychology from which models have been derived to account for the misconceptions children have regarding natural phenomena and explanations for their persistence in children's conceptual frameworks (see Osborne and Wittrock, 1983). Others (see Driver and Oldham, 1986) have forwarded instructional models designed to bring about conceptual change. An important stage in these models is the presentation of the discrepant event.

Special Needs and the Linguistically and Culturally Different As most students in the combined methods and student teaching sequence will be faced with the challenge of providing for the specific needs of learning handicapped or disabled and/or linguistically and culturally different students, we ask that these prospective teachers give attention to these students in their lesson planning. Our goal in doing so is to help teachers apply the knowledge acquired in previous coursework out of Chicano Studies, Pan-African Studies, Linguistics and Special Education departments to the practical realities of the classroom. Several strategies for providing for these

students are raised for discussion, critique, and their applicability to particular hypothetical teaching situations.

Assessment Our examination of the issue of evaluating students has several angles. One concerns developing means of assessing students in various stages of the instructional process. Students develop means for diagnosing student skills in computation and level of conceptual understanding of mathematical concepts to facilitate decisions regarding where instruction should begin for each student. Students combine strategies (e.g., paper and pencil measures and individual structured interview) to detect student shortcomings in computational skill and what students understand of concepts. The subject of evaluating students during instruction, the central focus of which is usually the value and techniques for checking for understanding, in our view, should also give attention to developing and using devices (e.g., tally sheets and anecdotal record forms) to assess students developing process and social skills. On the topic of post-instructional evaluation, our efforts are directed away from paper and pencil tests, particularly in the case of science, and towards developing more creative and meaningful strategies through which students can demonstrate what they have learned and acquired in skill.

On another level, our concern surrounds the informative value of the assessment process. Evaluation serves to inform a teacher of more than what students have learned, for in addition, analysis of the results of student assessment provides windows through which teachers can and should examine their effectiveness as instructors or guides and the effectiveness of the curriculum provided for student engagement.

Unit Planning During the course of the fifteen week semester, students develop unit plans and/or student teaching portfolios, either prior to the onset of student teaching or as student teaching unfolds. Long-range planning contributes to students' awareness of the value of curriculum development as part of pedagogical decision making. As in their planning lessons for daily instruction students give consideration to a number of criteria: the broad goals of engaging elementary students in a study of the unit topic, requisite skills and understandings, possibilities for cross-disciplinary teaching of these units, and so forth. Articulation of the terminal objects is of particular importance for these should be consistent with what the teacher considers to be the aims or purposes of an education in the sciences, e.g., an openness to engage in independent inquiry, a developed interest in mathematics and science-related topics, literacy in these disciplines, an understanding of the nature of mathematics and science.

The lessons of these units must reflect a wide range of instructional strategies, from more directed instruction incorporating manipulables to open-ended inquiry teaching in group situations. The strategy taken must be consistent with the specific objective(s) of the lesson and the terminal

goals of the unit. Through such varied approaches, it is hoped that teachers will develop facility in implementing many rather than merely a few strategies, will be open to experimenting with them in an effort to meet their needs and the needs of students, and come to make better decisions regarding alternate strategies and their consistency with more immediate and long-range goals.

If students design curricula for instruction during their student teaching, there is opportunity to make immediate use of the context and self-analysis of one's teaching as feedback in the design of units for instruction. The best-laid plans can go awry and we ask students to self-critique each lesson they teach, giving particular attention to those instances when their teaching, for whatever reason, does not proceed as planned. In their self-analysis of their teaching, teachers respond in three areas: (a) the nature of the difficulty encountered; (b) the source of the difficulty whether it be incorrect assumptions made on their part, student readiness, teacher preparedness, selection of materials, poor planning, and so forth; and (c) the knowledge provided by the experience and what, if any, measures might be taken in similar situations in the future to circumvent the problem encountered. In other words, we want teachers to "take a look back" at their teaching to determine what in particular contributed to the success of the lesson and what detracted from what could have been a most successful teaching situation.

Curriculum Analysis and Use: Textbooks and other Curricular Materials A trend toward school-based management in Los Angeles Angeles Unified School District will provide teachers the opportunity to assume roles and the associated responsibilities not available and required of them in the past. In the dimension of curriculum, their involvement will touch on the areas of school-wide and grade level curriculum development and the selection of textbooks and other learning materials. Discussion has been provided of our efforts to involve students in the curriculum building process during their student teaching experience. We view it equally important that teachers have a base for the decisions they will be faced with regarding the adoption of school and grade level textbooks and other materials to support the curriculum. Two projects are specific to the end of helping students to make use of their knowledge base and develop the intellectual skills to analyze the great variety of curricular materials currently on the market and in the future.

Students, in groups, access one of three kinds of science program, either a "process program" (e.g., ESS, SAPA, SCIIS) that grew out of the national effort to improve mathematics and science education in the post-Sputnik era, a more recently developed program (e.g., Project AIMS, FO/D), or a textbook series adopted by California for use in the districts within the state (e.g., Silver Burdett) for review and analysis. In their critique of the program or series, students determine and provide information regarding the goals/objectives and provide a "character sketch" or brief overview, which includes statements centering on what has been omitted from the text as well as included. (In the case of a textbook series, students may select a grade level and review the

materials intended for use at that grade level). The students' task continues with an analysis and interpretation of how the program's developers or series authors view scientific knowledge, the role(s) of the teacher and the student in teaching and learning science, the role of science in the student's life, and portrayal of the relationship of science to technology. Additionally, students outline what they consider to be the strengths and weaknesses of the program or series and discuss how they would (or why they would not) incorporate the program or series in their teaching of science at the elementary school level.

Similar examination is made of professional journals and magazines relevant to teachers of mathematics and/or science in the elementary school, many of which offer a rich source of ideas for incorporation in one's teaching. However, teachers ought not uncritically apply the ideas presented within to their teaching in these content areas. Three journals are chosen for review that give "reasonable emphasis" to curriculum and instruction in elementary mathematics and/or science. For each journal, students are asked to do an analysis of the contents of the journal, its organization, and the nature of the curricular and instructional ideas offered.

Microteaching: Peer Analysis and Self-Critique of Teaching Episodes Teachers plan short lessons for presentation to groups of fellow teachers on mathematics and science topics using teaching strategies that range widely from direct instruction to guiding students in cooperative group situations. As structured, this activity benefits both "teacher" and "student". It provides opportunities for these prospective teachers to devise and implement lessons for teaching a topic from mathematics and/or science in an atmosphere in which mistakes and error in judgement are more easily tolerated. The experience is an avenue for teachers to engage in self-critique under the guidance of the instructor and to develop a suitable comfort level in welcoming a colleague to observe one's teaching with the intent of generating and giving constructive criticism aimed at improving one's teaching. Just as important is the flip-side of the observation/feedback process. Teachers need to be careful observers and conscientious students of teaching if they are to provide criticism and suggestions for alternate courses of action of value to their colleagues in their work.

Observation and Peer Coaching Students observe and participate in the classrooms of their assignment several times during the two weeks preceding the onset of student teaching and record their observations and interpretations of classroom transactions in a student teaching log. This marks the beginning of a written record that spans a ten week period. Journals are reviewed upon visitation to the classrooms of the student teachers and are responded to in writing or in the post-instructional conference with the student teacher. We have in mind a number of goals for students

as they observe in their classrooms and in the classrooms of other supervising and student teachers.

Multiple Perspectives These prospective teachers are encouraged to adopt different perspectives as observers, observer/participants, participant/observers, and participants in classrooms, interpreting classroom interaction as psychologist, sociologist, and anthropologist. It is only through particular lenses that one can begin to appreciate the richness of interacting elements of the classroom: children with textbooks, manipulables, bulletin boards, and learning centers; children as members of a group working collaboratively towards some common goal; children and teacher as members of a classroom culture.

Critical Analysis of Classroom Behavior A second benefit to come the careful and analytic classroom observer is the development of a keen and critical eye that can peer beneath the surface of classroom interactions. While educating the young is a purposeful process, not all actions taken on the part of the teacher are directed towards some conscious desired outcome. Teachers often can not articulate the reasons underlying particular behaviors. The hidden curriculum of the classroom is as important, if not more so, than the explicit curriculum presented in school and grade level documents and scribed in teachers' planning books. As a critical observer of classroom transactions during their student teaching experience, we hope that these teacher aspirants will develop skill as careful observers, a heightened awareness of their own practice and the practice of others, and a better understanding of the implications of their actions.

Peer Coaching Some mention of the value of teachers observing in each other's classrooms has already been made. We are at times blind to our own actions and routines and need the input provided in the perspective of a colleague in making decisions with the goal of more effective practice. Student teachers make arrangements to be away from the classroom to which they are assigned for the purpose of observing in the classrooms of fellow student teachers. The period of observation is followed by a session of peer coaching for which the observer provides a critique of the lesson observed. The critique revolves around the explicit behaviors of the teacher, student reactions to those behaviors, and a discussion of the consequences of the teacher's actions. Additionally, the observing student teacher may offer suggestions of alternate courses of action to take in the context of the lesson taught. In this manner, sharing of specific and more general strategies helps teachers to broaden and deepen their repertoire of pedagogical skills.

Supervision During the eight weeks of the student teaching assignment, instructors/supervisors make five to six visits to each of the classrooms of the supervising teachers with whom student

teachers are placed. The purpose of the visits is to observe students in their teaching, critique lessons observed and to provide constructive feedback to help teachers improve their practice. The conferences that are part of these visits are important in he opportunities they provide instructor-supervisors to help students be more mindful of their specific teaching behaviors. Meetings with students in this context have two focal points: the specific lesson observed and the growth of the student teacher over the eight weeks of the student teaching assignment.

Several documents made available by the student teacher serve as springboards for discussion during conferencing. Students complete a pre-conference self-analysis outlining the goals jointly set by the supervising and student teacher and which the student teacher has met; the goals or hurdles the student teacher is directing efforts to overcome; particular aspects of the lesson the student teacher wishes to direct attention to; and questions, concerns, or comments the student teacher may wish to address in conference.

A lesson plan prepared by the student teacher provides an overview of the lesson to be taught. Lesson plans take the form discussed earlier in the section on lesson and unit planning. Student teachers justify the selection of objective(s), explicate processes children will engage in , discuss providing for special needs and linguistically different students, and outline their means of evaluating students. The value of the lesson plan to the conferencing situation is in the avenue it provides for discussion of the consistency between intended and actual teaching. Any deviations from the plan are important topics and are discussed in terms of reasons for departure.

Student teaching logs are available as a means for gauging student growth as a reflective practitioner and involvement in the affairs of the immediate classroom and the larger school environment. The logs serve as a record of observations and interpretation of interactions in various contexts and provide avenues for critiquing classroom and school practice, both their own and what is observed of others.

During visits to the classroom of student teachers, instructor-supervisors make detailed narrative notes which, in addition to serving discussion of the lesson observed, are used to chart a teacher's development through the student teaching assignment. While the narrative notes are largely an account of the observable behaviors of the teacher and students, conferencing extends beyond discussion of behaviors to include analysis of various aspects of the teaching observed. In the conferencing session, attention is given to the consistency between the student teacher's intentions and specific contextual factors of the classroom, and between intentions and behaviors. The content of what is taught in the lesson is given high priority, in particular the consistency between practice and the substantive and syntactic structures of the discipline that the topic falls under. A third conferencing topic is the hidden curriculum taught through the teacher's body motion, facial expressions, language, choice of curricular materials and how they are used, and so forth. Our

efforts here are to develop an awareness in teachers of the consequences, both intended and unintended, that are the result of specific teaching behaviors.

Seminars Instructor-supervisors hold weekly or bi-weekly seminars on a range of topics linked directly and more peripherally to the experiences of the student teachers in the schools. The seminar provides opportunities for discussion of issues surrounding teaching on two levels. On the one hand, it serves as a forum to address particular concerns regarding experiences of individual teachers in areas of classroom management, instructional decision making, and curriculum development. To the individual instances, other student teachers respond from a multiplicity of perspectives evolving a knowledge of alternate approaches to a given situation. On a second level, broader educational aims take center spotlight through which, it is hoped, student teachers' perspectives of teaching will deepen and broaden. Examples of such issues raised in discussion are ability grouping in mathematics and educational equity, aims and purposes of mathematics and science education, social interaction in inquiry in the classroom, assessment in mathematics and science teaching, and the role of the textbook in teaching.

Discussion and Summary

In this paper, we have delineated several assumptions that underlie the academic and professional coursework offerings and related field-based experiences to those seeking the California Multiple Subject Teaching Credential through California State University, Northridge. The program represents a concerted effort of several departments to endow teacher aspirants a broad knowledge base seen as essential to their work with students who hail from culturally, linguistically, and experientially diverse backgrounds. Student background as well as the social, political, and economic climates of the school and the surrounding community are seen as problematic and must be addressed in teachers' decisions concerning curriculum, instruction, assessment, and management. Therefore, teacher education must ready prospective teachers to exercise rational judgement in light of the particularities of a given context. The knowledge base generated through coursework and lived experience serves as guide in the decisions teachers make as to the appropriateness of their actions. Programs steeped in mechanistic ideology furnishing patterned responses to classroom situations is limiting of teachers and disserving of those who are the beneficiaries of an elementary education.

As a teacher's thinking is purposeful, directed towards ends that are judged to be worthwhile, it should be a primary goal of of teacher education to nurture the practitioner's capacity to engage in reflective activity. The practical knowledge of the teacher can be seen as functioning as an organized whole (Feiman-Nemser & Floden, 1986; Elzab, 1983), and we view our teaching of methodology as opportunity to contribute significantly to the organizational

process, drawing the teacher's knowledge base towards rational application in practical situations. We have given an account of the methods-student teaching sequence oriented towards this purpose, summarized in the model of the integration of methods in teaching mathematics and science in the elementary school and student teaching presented in the figure on the following page. At the intersection of the two components, theory is conjoined with practice in the course offerings and activities undertaken by pre-service elementary teachers during the seven weeks of methods and eight weeks of student teaching. The model represents our efforts to help these credential candidates to articulate and make sound use of an accumulated knowledge base as a guide to their actions.

Several features of the model are seen as facilitating an ability to maintain a close linkage between theory and practice in the education of teachers. One rests in the immediate fact that the provision of instruction in methods and supervision during student teaching is carried out by the same individual. Our role as teacher continues throughout the fifteen weeks of the semester, and we are in the best possible position to insure that those who are transitioning from student to teacher[3] substantiate their pedagogical decisions and actions with reference to their knowledge base.

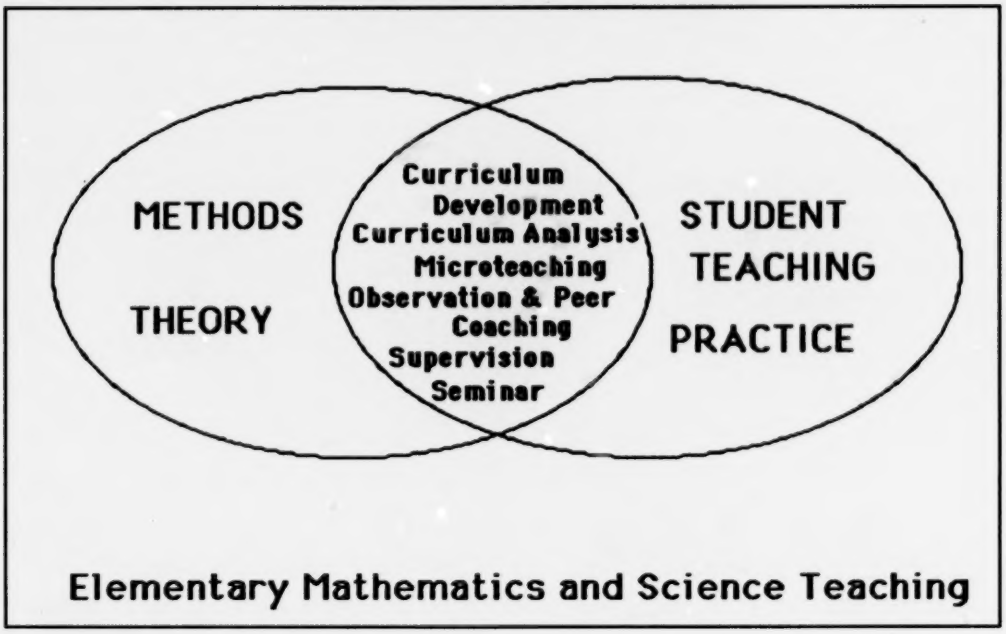
A second feature is in the emphasis given to teachers' growth as curriculum developers and users. While some teacher education programs cast teachers into the role of pedagogical managers set with the task of implementing a received curriculum, our attention is given more to teachers' involvement in the creation of curriculum to best meet their own needs and the needs of their students, supplementing their efforts with supporting materials such as textbooks, curriculum guides, and other varieties of teaching and learning materials.

The model illuminates a third feature, the concentration given to pre-service teachers' growth in their capacity for analytical and evaluative work. An intellectual quality is of tremendous import in all aspects of teaching whether it be in the determination of ends, critical assessment of broader educational issues, observing in classrooms, or reviewing curricular materials for adoption.

A fourth feature rests in the role of the teacher's accumulated knowledge base as a guide to practice. As we have argued, a primary goal of this professional education is to nurture teachers as reflective practitioners who make pedagogical decisions in light of what they know of subject matter, learners, social contexts, cultures, and the purposes of an elementary education.

We believe the CSUN model depicting a close linkage between methods and student teaching is conducive to teachers developing as reflective practitioners and can serve as a framework for restructuring other elementary teacher education programs serving a similar clientele. While the link is established for the purposes of guiding the pre-service teacher's

Integrating Science/Math Methods and Student Teaching: A Model



Curriculum Development
- Collaboration
- Valuation of ends
- Determination of means
  - Process
  - Open-exploration
  - Learning modalities
  - Special needs
  - Culturally & linguistically diverse
  - Self-concept
  - Mis- and pre-conceptions
  - Nature of mathematics & science
- Instructional models
- Assumptions
- Assessment
- Unit planning

Curriculum Analysis
- Mathematics and science programs
- Textbooks
- State frameworks
- Curriculum guides
- Learning materials
- Journals
- Magazines

Microteaching
- Self-critique
- Peer critique

Observation & Peer Coaching
- Journals
- Multiple perspectives
- Critical analysis of classrooms
- Peer coaching

Supervision
- Daily lessons
- Student Teacher Growth
- Self-analysis
- Intentions and actions
- Anecdotal records
- Consideration of contextual factors
- Lesson content
- Implicit curriculum

Seminar
- Individual experiences
- Educational ends and means

knowledge base toward its application in the eight weeks of practice teaching, our efforts are ultimately directed towards an individual's continued growth as an in-service teacher. As teacher educators, we have a responsibility to contribute to the campaign of reform of the professional education of teachers so that they may carry the campaign to the broader purpose of reform of education in general. To that end, we need prospective teachers who are both theoreticians and practitioners, who can combine theory, imagination, and techniques (Giroux, 1990; p. 8).

NOTES

1. California awards "preliminary" and "clear" multiple subject teaching credentials. A number of students complete all requirements for the latter prior to applying to the state for a credential. Others earn the preliminary credential, find employment and complete additional requirements towards the clear in the five years following. The program delineated here is the "fifth year" leading to the preliminary California Multiple Subject Teaching Credential.

2. Dewey (1904) remarked that student teachers need to adopt different perspectives (e.g., psychological, sociological) in observing in classrooms. Insight and initiative is gained through a developed ability to view the intellectual interaction between various elements in the classroom.

3. Most students, having fulfilled the mathematics and science methods and the second semester of student teaching requirement, are eligible for the preliminary credential and immediately seek employment. It is in this sense that it can be said that they are *transitioning* from the life of a student to the world of work, not that they do not continue to be students of education.

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